TECHNICAL PAPER 1.

MARINE FISHERIES RESOURCES, FISHERIES AND MARINE ENVIRONMENTAL MANAGEMENT, CORAL REEFS AND MARINE PARKS IN THE NORTHWEST INDIAN OCEAN

by

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1. INTRODUCTION

The fishing area in the northwest Indian Ocean is approximately 2.4 million km^2 (≈8% of Western Indian Ocean (FAO Statistical Area 51 (FAO, 1997)) and consists of six major marine productive areas: Eastern Arabian Sea, Arabian Gulf, Gulf of Oman, Northern Arabian Sea, Gulf of Aden, and Red Sea. These have diverse resources of fish, shellfish, reptiles, mammals, birds, coral reefs, aquatic plants and mangroves. Many areas in Gulf of Aden and Arabian Sea are subject to seasonal monsoon upwelling, causing periodic high plankton production in the coastal waters, which is followed by high fish production. Fish productivity (t/km^2) is high in Gulf of Aden, Eastern Arabian Sea, Arabian Gulf and Gulf of Oman; and low in North Arabian Sea and Red Sea (Table 1). The main exploitation patterns of the coastal marine resources are that two countries (India and Pakistan) operate in the Eastern Arabian Sea; seven countries (Iran, Iraq, Kuwait, Saudi Arabia, Bahrain, Qatar and UAE) in the Arabian Gulf; two countries (Iran and Oman) in the Gulf of Oman; three countries (Djibouti, Somalia and Yemen) in the Gulf of Aden; and seven countries (Saudi Arabia, Jordan, Israel, Egypt, Sudan, Eritrea (formerly Ethiopia) and Yemen) in the Red Sea. In addition, a number of foreign fleets (from Russia, CIS, etc., other countries of eastern Europe and the Far East) have tapped the demersal and pelagic fish resources in deep waters through contractual agreements.

Table 1. Approximate fishing area and fish production by region in the Northwest Indian Ocean

Region	Approximate area ($\times 10^6$ km^2)	Fisheries production (t and (t/km^2))	
		1987	1996
Eastern Arabian Sea	1.1[(1)]	1 451 576 (1.3)	2 424 166 (2.2)
Arabian Gulf and Gulf of Oman	0.3[(2)]	365 162 (1.2)	471 865 (1.6)
Northern Arabian Sea	0.5[(1)]	72 987 (0.1)	50 885 (0.1)
Gulf of Aden	0.05[(3)]	74 921 (1.5)	95 946 (1.9)
Red Sea	0.44	63 250 (0.1)	105 016 (0.2)
Total for northwest Indian Ocean	2.39	2 027 896 (0.8)	3 147 878 (1.3)

Notes: (1) Rough estimate from the map. (2) Rough estimate from the map for Gulf of Oman, added to Arabian Gulf (Siddeek, Fouda and Hermosa, 1999). (3) Sanders and Morgan, 1989.

Marine trade and fisheries in the northwest Indian Ocean have existed for centuries, but proper recording of resource exploitation by many coastal countries, especially those of the Arabian peninsula, started only one or two decades ago (Siddeek, Fouda and Hermosa, 1999). Thus, the current comparative analysis of fisheries data is largely restricted to the last decade for fish production. However, a longer time-series of data on shrimp production in the Arabian Gulf has been included because of its importance to the region. Effort statistics for many countries have not been well documented. Therefore, catch trends have been analysed to explore the stock trends, even though catch-per-unit-effort would have been the best choice for this type of analysis.

Fish production in this region has been increasing in the last decade and reached 3.1 million t (t) in 1996 (Table 1). The driving force behind this increase has been the rapid development of international trade, within and outside the region, in valuable fish products such as shrimp, cuttlefish, lobster, narrow-barred Spanish mackerel, grouper, tuna, and many species of pelagic fish, demersal fish and shellfish.

This region covers tropical and sub-tropical environments sustaining multispecies fisheries resources. Demersal fisheries for shrimp and fish are prominent in countries bordering the Arabian Peninsula. Large pelagic species like tuna and Spanish mackerel are also heavily exploited, primarily in the Arabian Sea. The fisheries are of a multigear nature and dominated by artisanal fisheries, which contribute over 80% in many countries.

Shrimp fisheries provide valuable foreign exchange to India, Pakistan and countries bordering the Arabian Gulf. Shrimp fisheries, especially those in the Arabian Gulf, developed in the late 1960s (FAO, 1982) and use primarily trawls. The contribution from castnet fishery in the Gulf of Masirah, Oman, is insignificant compared to catches along the west coast of India, Pakistan and the Arabian Gulf.

Among the valuable demersal species, groupers (Serranidae) and emperors (Lethrinidae) are significant in the catch of countries bordering the Arabian Peninsula. Grouper is caught primarily by fish traps and emperors by fish trawl nets. Croakers (Sciaenidae) are an important demersal fish component, primarily caught by shrimp trawls on the west coast of India and Pakistan.

Small pelagic fish, dominated by sardinella species and Indian mackerel (*Rastrelliger kanagurta*), are caught in large quantities primarily by small-mesh surface gillnets and beach seines throughout the coastal upwelling areas, from the west coast of India to the east coast of Egypt. Coastal migratory large pelagic fishes, narrow-barred Spanish mackerel (*Scomberomorus commerson*) and longtail tuna (*Thunnus tonggol*), are caught in significant quantities, primarily by large-mesh gillnets, and the highly migratory oceanic yellowfin tuna (*Thunnus albacares*) are caught in large quantities by gillnets and longlines, in the coastal and oceanic waters from the west coast of India to the east coast of Egypt.

Of the invertebrates, cuttlefish and spiny lobster is caught in significant quantities on the south coast of Oman and Yemen. While the former is caught largely by industrial trawlers, the latter is harvested by trammel net and lobster pots. The abalone fishery is unique to the Dhofar coast in southern Oman. It is operated by skin diving using bare hands and knife. Although the harvest level is small (34-105 t during 1987 to 1996), the product fetches a very high price (US$ 155 000/t) in Far Eastern markets.

Only the west coast of India produces aquatic plants (brown, red and green seaweed) in commercial quantities (FAO, 1998).

Populations in the region have been rapidly increasing in recent decades, and so has the fisher population, which strains the limited wild fish and shellfish resources. In order to supplement the wild catch and to earn foreign exchange, countries have embarked on aquaculture and mariculture, and this sector has grown steadily since the early 1980s, with countries focussing primarily on shrimp farming in coastal estuaries and bays. Mariculture of commercially important fish is also becoming popular in many Arabian Gulf countries.

This paper reviews available information on fisheries on the continental shelves of the six water bodies in the northwest Indian Ocean by describing the marine environment, fishing methods, fish and shellfish resources, the current status and trends in yield, and existing fisheries and marine environmental management regulations. This is intended for use in setting up appropriate monitoring, control and surveillance (MCS) activities in countries of the northwest Indian Ocean.

2. FISHERIES REGIONS

2.1 Eastern Arabian Sea

Western India and Pakistan have a total coastline of over 3 000 km along the eastern Arabian Sea. The continental shelves in this region are broad, with lucrative demersal and pelagic fishing grounds. Furthermore, seasonal upwellings enhance overall fish productivity. Thus, fish production on the west coast of India accounted for over 85% of the country's total in 1996 (FAO, 1998). Because of very few rivers flowing into the Arabian Sea from the mainland, coupled with the influence of high temperature and high salinity water masses from the western Arabian Sea,

the salinity is high in the Arabian Sea off India, and ranges from 34‰ to 37‰ (in PSU). The sea surface temperature ranges from 21 to 29°C (Bal and Rao, 1990).

2.2 Arabian Gulf

The Arabian Gulf extends from Iraq (Shatt Al-Arab delta) in the northwest to the Gulf of Oman, through the Strait of Hormuz in the southeast (Figure 1). It is approximately 1 000 km long, 200 to 300 km wide and with a surface area of 226 000 km^2. It is shallow, gradually sloping from the Arabian Peninsula to deeper waters in the southeast, reaching 80-100 m in the Strait of Hormuz. The bottom sediments are mostly soft mud, suitable for trawling, with a few outcrops of corals (FAO, 1982). In some areas, particularly embayments, dense seagrass beds have developed. It receives very little precipitation and is always subject to high evaporation due to high solar radiation levels. The wide seasonal changes in air temperature result in sea temperatures varying from 15°C in winter to 33°C in summer. In the Arabian Gulf, there are dramatic variations in salinity, ranging from 37 to 50‰ or more, compared to 35-39‰ outside in the Indian Ocean, because it is shallow and water exchange with the Indian Ocean through the Strait of Hormuz is limited.

2.3 Gulf of Oman

Coastal waters of the Gulf of Oman stretch from the Strait of Hormuz in the northwest to the eastern tip of the Arabian Peninsula (Ras Al-Hadd) on the Oman side, and to Gwatar near the Pakistani border on the Iranian side (Figure 1). The stretch from Muscat to Sur shows quite a steep bathymetry to depths exceeding 2 000 m, with very limited shelf, whereas in the northeast, off Muscat, the shelf is well developed, but narrower than that of the Arabian Sea. The bathymetry on the Iranian side, however, is no steeper than that on the Oman side. The sea surface temperature and salinity are higher than in the Arabian Sea, ranging from 22°C to 32°C and 36‰ to 37.5‰, respectively (Siddeek, Fouda and Hermosa, 1999).

2.4 Arabian Sea

A large part of the Oman coastline faces the Arabian Sea. Except for the western part of Dhofar, the continental shelf is well developed and relatively large. The shelf bottom consists of large, trawlable areas off Masirah Island, with rocky areas and coral outcrops to the south. The shelf bottoms are periodically affected by southwest monsoon-driven upwelling that transports cooler, nutrient-rich water from depths below 200 m. The coastal upwelling nuclei are found all along the Yemen, Oman, Iran and Pakistan coasts, up to western India. The sea surface temperature ranges from 21° to 28°C, but may drop to as low as 18°C in coastal upwelling nuclei, with salinity from 35.5‰ to 36.5‰ in open waters.

2.5 Gulf of Aden

The Gulf of Aden extends eastward from the Red Sea to a line between Ras Fartak (Yemen) and Ras Asir (Somalia). Its continental shelf is narrow, with an area of approximately 50 000 km^2, extending up to 200 m depth, and slopes steeply from the shore. There are no fringing coral reefs because of the spread of cold and turbid water from coastal upwelling areas (Sanders and Morgan, 1989). The shelf bottom is likely to be similar to that of the Dhofar coast (Sheppard, Price and Roberts, 1992). Because of high solar radiation levels, the surface temperature is high, averaging 40 to 43°C during summer, and the salinity is also high (Morcos, 1970).

2.6 Red Sea

The Red Sea is a long narrow basin with a total length of approximately 2 000 km, average breadth 280 km, and area 440 000 km^2. It is much deeper than the Arabian Gulf, with an average depth of 500 m. The deepest part in the Red Sea reaches 2 500 m. The Sinai Peninsula divides

the northern part into the shallow Gulf of Suez and the deep Gulf of Aqaba. The depth in the Gulf of Aqaba reaches 1 000 m, with narrow shelves, whereas in the Gulf of Suez the depth is 30-40 m in the north, steadily increasing towards the south to 70-80 m, with a flat bottom. The continental shelf area of the Red Sea to 200 m depth is approximately 180 000 km^2. The Red Sea is characterized by shallow coral reefs, numerous in the southern half, occurring at depths less than 50 m and with widths varying from a few metres to 500 m or more. Because of high solar radiation levels and a low input of fresh water, the Red Sea's surface temperature and salinity are higher than in the Gulf of Aden; salinity averages 36‰ near the Gulf of Aden and increases to more than 40‰ in the north (Fouda, 1998). In the Red Sea, the temperature peaks annually in August/September, whereas there are two peaks per year in the Gulf of Aden – in May/June and September/October – because of upwellings (Sanders and Morgan, 1989).

3. CURRENT STATE OF FISHERIES

Most artisanal fisheries in the northwest Indian Ocean start at the end of summer (August or September) with the recruitment of young fish and invertebrates to the fishery. Fishing intensity is drastically reduced, if not halted, at the start of summer (June or July). In Oman, the industrial trawl and longline fisheries are conducted by foreign fishing companies, as well as by local companies, throughout the year, and they use the logbook system to record catch and effort. Other countries also apply the same recording system for their industrial fleets. In contrast, the artisanal catch and effort data are collected by a sampling programme in almost all the countries in the region.

To prepare this review, recourse was had to data from fisheries statistics reports of the various countries, FAO, local research agency reports, workshop proceedings and unpublished documents.

Because of difficulties in separating certain country statistics, the catch data for the Arabian Gulf and Gulf of Oman are combined in this review. For categorization of catch data into small pelagic, large pelagic and demersal, the following groupings were used:

(i) ***Small pelagics*** Sardines (Clupeidae), anchovies (Engraulidae), Indian mackerel (*Rastrelliger kanagurta*), hilsa shad (*Tenualosa ilisha*), halfbeaks (*Hemirhampus* spp.), Bombay duck (*Harpadon nehereus*), flyingfishes (Exocoetidae), mullets (Mugillidae), needlefishes (*Tylosurus* spp.), and silver biddies (*Gerres* spp.).

(ii) ***Large pelagics*** Barracudas (*Sphyraena* spp.), jacks (Carangidae), large scombroids (*Scomberomorus* spp. and *Acanthocybium* spp.), tunas (*Thunnus albacares*, *T. tonggol*, *Auxis thazard*, *A. rochei*, *Euthynnus affinis*), cobia (*Rachycentron canadum*), marlins and sailfish (Istiophoridae), sharks, rays and skates (Elasmobranchii and Rajiformes).

(iii) ***Demersals*** Flatfishes (Pleuronectiformes), catfishes (Ariidae), ponyfishes (Leiognathidae), goatfishes (*Upeneus* spp.), croakers (Sciaenidae), groupers (*Epinephelus* spp.), snappers (Lutjanidae), emperors (Lethrinidae), spinefeet (*Siganus* spp.), sweetlips (Haemulidae), hairtails (Trichiuridae), seabreams (Sparidae), silver pomfret (*Pampus argenteus*), spiny lobster (*Penulirus* spp.), slipper lobsters (Scyllaridae), cuttlefishes (Sepiidae), shrimps (Penaeidae), squids (*Loligo* spp.), and crabs (Portunidae).

3.1 Fishing gear and vessels

Industrial fleets (company owned) use trawls, longlines, surface gillnets and purse seines, whereas artisanal vessels employ various types of fishing gear in exploiting pelagic and demersal fish resources. The industrial trawlers belong to two groups: (1) demersal fish trawlers (vary in vessel and gear size, and operate in coastal shallow and deep (>50 m) waters within the continental

shelf); and (2) shrimp trawlers (smaller vessels and gear size compared to fish trawlers, and operate in coastal shallows (<50 m)).

The artisanal fisheries use small-mesh gillnets, large-mesh gillnets, encircling nets, shrimp trawls, traps (*gargoor* – wire-mesh type for fish and invertebrates and plastic-type solely for lobster), bottom gillnets, trammel nets, barrier traps (*haddrah*), hand lines, pole and lines, troll lines, longlines, and even bare hands and knives (by skin divers in the Oman abalone fishery) to exploit the pelagic and demersal resources in the coastal waters. While artisanal shrimp trawling is conducted by large wooden, fibreglass or steel-hulled mechanized boats; the other gear are operated by those vessels as well as small fibreglass boats (4-11 m) with outboard motors, and various indigenous craft with and without outboard motors (Bal and Rao, 1990; Siddeek, Fouda and Hermosa, 1999). Beach seines are widely used in the coastal waters of various countries to catch sardines, anchovies, other coastal small pelagic fish, and juveniles of many pelagic and demersal species.

3.2 Fisheries resources

Over a thousand species of fish and invertebrate have been identified from this region (Bal and Rao, 1990; Fouda and Hermosa, 1993; Randall, 1995). Among them, Indian oil sardine (*Sardinella longiceps*), Bombay duck (*Harpadon nehereus*), Indian mackerel (*Rastrelliger kanagurta*), many sardinella species and anchovies (Engraulidae) support the small-mesh gillnet, beach seine, and purse seine fisheries in the northwest Indian Ocean. Similarly, narrow-barred Spanish mackerel (*Scomberomorus commerson*), longtail tuna (*Thunnus tonggol*), yellowfin tuna (*Thunnus albacares*), kawakawa (*Euthynnus affinis*) and various pelagic sharks, skates and rays (Elasmobranchii and Rajiformes) sustain valuable large-mesh gillnet, longline and troll line fisheries.

Over 350 fish species (the majority belonging to Sciaenidae, Lethrinidae, Serranidae, Siganidae and Trichiuridae), eight shrimp species (*Penaeus semisulcatus, P. merguiensis*, *P. indicus*, *P. monodon, Parapenaeopsis stylifera*, *Metapenaeus affinis, M. stebbingi* and *M. monoceros*), two spiny lobster species (*Panulirus homarus* and *P. versicolor*), shovelnose lobster (*Thenus orientalis*), cuttlefish (*Sepia pharaonis*), abalone (*Haliotis mariae*), one crab species (*Portunus pelagicus*) and a number of sea cucumber species (Holothuridae) provide the basis for the demersal fisheries in the study area (Mohammed, Al Musa and Abdul-Ghaffar, 1981; Johnson, Al Harasy and Al Harthy, 1992; Krupp and Muller, 1994; FAO, 1998). Pearl oysters (*Pinctada margaritifera* and *P. radiata*) had been harvested in the Arabian Gulf in the past, but the pearl fishery died towards the middle of this century (Sheppard, Price and Roberts, 1992). Although commercial oyster fisheries are currently non-existent, there are moves to revive the pearl oyster fishery in many Arabian Gulf countries (e.g., Iran).

3.3 Trends in landings

3.3.1 Northwest Indian Ocean

There has been a steady increase in the annual total marine fish, shellfish and other aquatic resources production in the northwest Indian Ocean. The total annual marine harvest for this region ranged from 2 027 896 to 3 147 878 t during 1987-1996 (Tables 1 and 2). Almost all of this was harvested from the territorial waters and within the continental shelf. The small pelagic resources contributed approximately 24.5%, large pelagics 14.8%, and demersal 29.9% to the total landings in 1996. This picture is blurred by the presence of a large percent (30.8%) of unidentified fish and shellfish. However, it is apparent from that the steady increase in landings is due to increase in catches in all three groups of marine resources.

Among the fish group, sardine, Indian mackerel, narrow-barred Spanish mackerel (kingfish), and longtail tuna provide the greatest contribution (hence fishing effort and revenue) to

Table 2. Major fish and shellfish species landings in northwest Indian Ocean for 1987 to 1996.

Species	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
Small pelagics										
Bombay-duck	87650	97792	116676	124509	142618	153925	142244	126517	133884	159463
Indian oil sardine	198176	209783	258617	293587	208680	213627	197537	132506	125037	137467
Anchovy	40106	62277	63003	100821	94959	95618	61865	73880	75201	68137
Indian Mackerel	57351	59115	156075	119683	85845	92936	128208	200218	187216	261981
Large pelagics										
Barracuda	9466	8942	10738	11121	13986	14505	14935	15543	15055	10470
Queenfish	1781	1866	1950	1739	1723	1790	2053	2661	3361	3282
Trevally	44536	58847	131923	141390	165207	180294	152068	105376	73589	70903
Narrow-barred Spanish mackerel	67296	74571	55260	48682	45701	58514	55434	59120	70029	67949
Indo-Pacific king mackerel	10738	13592	17163	13088	18240	14284	17327	14929	19489	22992
Yellowfin tuna	7753	19336	27108	24435	20756	51660	67898	38970	57221	57115
Longtail tuna	37355	41359	36143	33727	31899	26160	25718	31404	47917	40957
Kawakawa	19765	25945	32628	40055	23885	30750	21289	23814	29018	37480
Shark, ray & skate	69771	72148	73282	73451	80646	88799	91579	94876	100341	97708
Demersals										
Grouper	17411	22361	19690	20315	19456	23387	25037	28048	27099	28409
Snapper	8556	9584	9129	7929	9376	9693	13313	17511	16900	14273
Sweetlip	7342	10009	7445	6686	8032	7800	9399	9460	12606	11841
Emperor	21194	27103	25909	23928	25498	27405	31765	29978	32037	31182
Croaker	151400	149732	197458	215700	235509	257237	271180	305749	273543	254086
Seabream	8386	15511	10334	10994	10019	11761	12517	14786	15595	12472
Spinefeet	2188	2168	2281	2060	2317	2024	2142	1988	2381	3071
Hairtail	690	4300	5075	2911	5087	3959	3021	3954	8214	6432
Catfish	43706	54084	44102	48101	56927	55868	70731	76518	79990	78862
Shellfish										
Penaeus shrimp	213958	221885	214639	229065	295891	270841	228594	265691	206227	265959
Spiny lobster	3573	3702	3893	4398	4570	2555	2874	2397	2202	2032
Cuttlefish and squid	26540	38077	40433	30279	61185	70325	75140	96597	106001	90324

total landings compared to other species, and hence their trends are analysed. The first two – small pelagic fish – are exploited using small-mesh gillnet, cast net, and beach seine by artisanal craft, while the last three – large pelagic fish – are caught by large-mesh gillnet, troll line, and longline by artisanal as well as industrial vessels. Kingfish is the most popular table fish, demanding a higher price per kg than any other fish in the region (Al-Hosni, 1996). Kingfish and longtail tuna production dropped slightly in the early 1990s, and thereafter the kingfish catch improved slightly in recent years whereas longtail tuna landings dropped in 1996 after an increase in 1995. The trends in catches of the two coastal migratory large pelagic fish – kingfish and longtail tuna – are similar. In contrast, sardine (primarily Indian oil sardine (*S. longiceps*)) and Indian mackerel (*R. kanagurta*) production show opposite trends: when one is abundant, the other is sparse. This has been shown by Longhurst and Pauly (1987) using a long time-series of data for the west coast of India comparing sardine and mackerel, and is primarily due to the sardine's restricted food preference. The sardine catch peaked in 1990 at 427 579 t and dropped thereafter. As the sardine landings fell, Indian mackerel landings increased, and reached 261 981 t in 1996.

Exploitation of shrimp, lobster and cuttlefish resources in the northwest Indian Ocean provides valuable foreign exchange for many of the countries. Shrimp is primarily caught by artisanal and industrial trawlers, with the exception of Oman fishery, where cast nets are used. Lobster is harvested by artisanal boats using trammel nets, lobster pots and diving, while cuttlefish is taken by artisanal vessels using spears and pots and by industrial vessels using trawls. The shrimp catch fluctuated between 213 958 and 295 891 t during 1987-1996, with a peak in 1991. Cuttlefish production (with an insignificant amount of squid) has been steadily increasing, from 26 540 t in 1987 to 90 324 t in 1996. The primary reason for the increase in Oman's cuttlefish landing is the increase in the industrial fishery share. Lobster landings in the region have been steadily dropping, from a peak of 4 570 t in 1991 to 2 032 t in 1996. Destructive fishing methods, such as use of trammel net and catching of egg-bearing females, have been blamed for this drop.

Table 2 provides the major fish and shellfish species landings in the Northwest Indian Ocean for 1986 to 1996. Shrimp topped the list followed, by Indian mackerel and croaker in 1996. Eastern Arabian Sea production contributed to this ranking.

3.3.2 Eastern Arabian Sea

There has been a steady increase in the annual total marine fish, shellfish and other aquatic resources production in the eastern Arabian Sea area, which is exploited by India and Pakistan. The total annual marine harvest for this region ranged from a low of 1 451 576 t to a high of 2 424 166 t during 1987-1996. The small pelagic resources contributed approximately 27.3%, large pelagics 11.6%, and demersals 36.0% to the total landings in 1996. A substantial percentage (25.1%) of unidentified fish and shellfish is also reported for this region. A systematic increase in demersal and unidentified category catches has contributed to the total increase.

Sardine and Indian mackerel landings during 1987 to 1996 clearly showing inverse trends. The sardine catch peaked at 373 617 t in 1990, but had dropped to 153 303 t in 1994, and slightly improved, to 172 284 t, in 1996. Prey species, such as sardine are well documented for boom-or-bust abundances (Longhurst and Pauly, 1987).

Looking at trends in tuna (treated as one group that includes *T. albacares*, *Katsuwonus pelamis*, *E. affinis*, *T. tonggol* and *T. obesus*) and the kingfish group (primarily *S. commerson*, but including *S. guttatus*, *S. lineolatus* and *Acanthocybium solandri*) landings, both groups show increasing trends, although the tuna catch has been more fluctuating than that of kingfish. Whereas kingfish is dominated by *S. commerson*, no one tuna species is dominant when catches of both countries are combined. The increasing trends appear to be the result of expansion of effort on the resources with the modernization of vessels in the two countries.

Looking at crustaceans and others, shrimp production has fluctuated, with a peak of 284 650 t in 1991 and a nadir of 192 132 t in 1987. 1996 production was 245 819 t, a 28% increase from 1987. Greater effort has been directed towards wild shrimp exploitation because of its export potential. Cuttlefish dominates the landings of that group, and the catch has systematically increased apart from drops in 1990 and 1996. Seaweed is exploited only on the west coast of India.

3.3.3 Arabian Gulf and Gulf of Oman

Total landings for Oman have been divided between the Gulf of Oman and the Northern Arabian Sea, and then the Gulf of Oman component added to Arabian Gulf data for this analysis (Anon, 1990 to 1998). Because of difficulty in separating Saudi Arabian landings into those for the Red Sea and those for the Arabian Gulf, following Sanders and Morgan (1989), the Saudi Arabian catches are divided into equal halves, one for each area. On this basis, the annual total marine landings in the Arabian Gulf and Gulf of Oman ranged from 365 162 t to 471 864 t in 1987-1996. The small pelagic resources contributed approximately 14.4%, large pelagics 29.5%, and demersals 18.9% to the total landings in 1996. A large percentage (37.2%) of unidentified fish and shellfish is also reported from this region. A systematic increase in the large pelagic fish share has largely contributed to the total catch increase.

Small pelagic fish are not significant in the catch in this area, and no sardine-Indian mackerel relationship is apparent.

Looking at the trends in longtail tuna, kingfish and yellowfin tuna catches, longtail tuna and kingfish catches show similar decreasing and then increasing trends, while the yellowfin tuna catch has steadily increased. The kingfish and longtail tuna catches dropped to 16 213 t and 24 052 t, respectively in 1996, from 1995 peaks of 25 173 t and 35 465 t, respectively. The drop in kingfish catches has been a major concern for Oman fisheries managers for the last few years. The drop has been attributed to various reasons, including heavy exploitation of young, immature, fish by small mesh gillnets, to recruitment failure from adverse environment. The drop in longtail tuna catch has not attracted much attention, presumably due to its low market value compared to kingfish. The increased trend in the yellowfin tuna catch may partly be due to increased effort and partly to high abundance of prey species in coastal waters, because of a lower predation by a reduced kingfish stock, thus attracting yellowfin tuna to coastal waters and making them vulnerable to heavy fishing.

Four species of shrimp (*P. semisulcatus, M. affinis, P. merguiensis*, and *Parapenaeopsis stylifera*) support the shrimp trawl fishery in the coastal waters of the Arabian Gulf. Each species has different areas of concentration. The primary fishing grounds of *M. affinis* and *P. stylifera* are in the northern Arabian Gulf along the shallow coastal waters off Kuwait, Iraq and Iran. *P. semisulcatus* stocks are associated with sea weeds and sea grasses (Basson *et al.*, 1977), prefer more saline water, and are dominant in the southern Kuwaiti and Iranian waters, and in coastal waters of Saudi Arabia, Bahrain and Qatar. *P. merguiensis* is associated with muddy and sandy bottoms, and is harvested from southern coastal waters of Iran on the Iranian side of the Gulf of Oman.

The industrial and artisanal trawl contributions to shrimp catch vary in different countries, but in Bahrain artisanal trawlers contributed over 99% in 1995 (Anon, 1996). There is no commercial shrimp exploitation in UAE, and limited shrimp fishing activities (<50 t annual landing) were traditionally conducted by Iraqis in Iraqi marshy lands (for *M. affinis*) and the Shatt Al Arab estuary (Mathews, Bishop and Salman, 1987), but recent exact catch data are not available.

Shrimp production in the Arabian Gulf and Gulf of Oman has declined from 17 642 t in 1987 to 9 727 t in 1991, and then steadily increased to 15 486 t in 1996. The 1991 drop was due

to the Gulf War, which disrupted fishing activities in Kuwait and neighbouring countries, and oil pollution further affected the shrimp resources in Bahrain, Kuwait and Saudi Arabia. Although shrimp fisheries have recovered since then, excessive fishing pressure appears to have limited the potential catches. The historical shrimp production data for this area show peak production in 1988-1989, then a drop in 1991 and 1992, and an increase thereafter. A number of fisheries management measures have been enforced in different countries, with varying degrees of success in sustaining shrimp resources.

Increasing cuttlefish and squid production, but a depressed lobster fishery, have been observed in this region as in other areas.

3.3.4 Northern Arabian Sea

The northern Arabian Sea contributes less than 50% to total Omani fish production; the 1997 contribution being approximately 46% (Anon, 1990 - 1998). Annual total marine landings in the northern Arabian Sea ranged from 39 254 t in 1994 to 72 987 t in 1987. The small pelagic resources contributed approximately 24.5%, large pelagics 41.7%, and demersals 25.9% to the total landings in 1996. A small percentage (7.9%) of unidentified fish and shellfish is also reported for this region. An increasing trend in large pelagic fish production, especially yellowfin tuna by foreign industrial longliners, has contributed to a steady increase in total landings from the 1994 minimum.

The sardine catch peaked in 1991, at 19 867 t, dropping to 7 661 t in 1997. The Indian mackerel catch is too insignificant (<1 000 t) to compare its trend with that of sardine. *S. longiceps* and *S. gibbosa* contribute over 99% of the total catch, with the former dominating. The beach seine fishery contributed over 90% of the total sardine catch. This production is mostly dried and used for cattle feed and fertilizer.

One can see the same declining trends as elsewhere in kingfish and longtail tuna landings in the northern Arabian Sea from 1987 to 1997. Yellowfin tuna catches, in contrast, fluctuated due to more effort being diverted to its exploitation.

Among crustaceans, two species of shrimp, *P. indicus* and *P. semisulcatus,* contribute over 99% of the modest shrimp landings in Gulf of Masirah, Oman. The annual shrimp catches ranged from 155 t in 1991 to 587 t in 1989, with 1997 landings at 376 t. Spiny lobster catches have dropped drastically, while the abalone catches remain steady, despite the short fishing season. Excessive fishing pressure on abalone, and illegal fishing methods as well as excessive fishing pressure on lobster, have been determined as leading to their decline. Cuttlefish production has systematically increased, from a 1987 level of 100 t to 2 713 t in 1997. Foreign industrial trawlers have been responsible for a large share of the cuttlefish catch.

Among the valuable demersal species caught in the Arabian Gulf, Gulf of Oman and northern Arabian Sea, emperors (Lethrinidae) are the most important species caught, followed by groupers (Serranidae), croakers (Sciaenidae), and rabbitfishes (Siganidae). Hairtails or ribbon-fishes (Trichiuridae) topped the demersal group (Siddeek, Fouda and Hermosa, 1999), while yellowfin tuna (*T. albacares*) topped the pelagic group in Oman in 1997 (Anon., 1990 - 1998).

3.3.5 Gulf of Aden

Based on past catch contributions by Yemen to Gulf of Aden and Red Sea total catches, as reported by Sanders and Morgan (1989), the annual catches are divided into 80% for the Gulf of Aden and 20% for the Red Sea. The annual total landing in the Gulf of Aden has systematically increased, from 74 921 t in 1987 to 95 946 t in 1996. A large percentage of unidentified fish and shellfish (64.0%) has contributed to this increase. The small pelagic resources contributed approximately 4.3%, large pelagic 14.1%, and demersals 17.6% to the total landings in 1996.

The sardine-Indian mackerel trends could not be explored for Gulf of Aden because of only one sardine catch reported in the period studied. Indian mackerel production was surprisingly low in 1996, which could be either an artefact of data or a real reduction in the catch. Having observed the stability of Indian mackerel resources in Indian Ocean waters, it is more likely an artefact than a true value.

Longtail tuna and kingfish production trends in Gulf of Aden for 1987 to 1996 show a picture differing from other areas: there has been a steady increase in production of both species. Total tuna production has also showed an increasing trend. However, a more detailed analysis would be needed to identify the reasons behind these increases.

Shrimp production in Gulf of Aden has been modest: from 197 t in 1990 to 785 t in 1995, and dropping to 532 t in 1996. The spiny lobster catch has been declining over the years, from 1 504 t in 1987 to 646 t in 1996, as found elsewhere, while cuttlefish production has shown an increasing trend after a drop in 1992 to 1994, and reached 1 900 t in 1996, up from a low of 845 t in 1994.

3.3.6 Red Sea

The annual total landings in the Red Sea have systematically increased, from 63 250 t in 1987 to 105 016 t in 1996. The small pelagic resources contributed approximately 9.7%, large pelagics 15.7% and demersals 48.7% to total landings in 1996. The contribution by unidentified fish and shellfish was 25.9%. Demersal fish (including reef fish) form a substantial part of the Red Sea landings. The steady increase in the total annual catch is attributed to the increase in demersal landings.

The sardine and Indian mackerel production trends for 1987 to 1997 in the Red Sea once again show opposite trends: as the sardine catch increases, the Indian mackerel catch decreases, and *vice versa*. The sardine catch peaked in 1989 at 6 291 t, dropped and built up again to a peak again of 7 758 t in 1996. Indian mackerel catches peaked in 1994 at 6000 t, and fell thereafter.

The kingfish catch has been dropping since 1994, whereas tuna catches have been increasing since 1993. Kingfish production trends in various areas in the northwest Indian Ocean have been decreasing, except for the Gulf of Aden, which deserves detailed investigation of the Gulf of Aden stock.

The Red Sea shrimp catch systematically fell from 3 593 t in 1987 to a minimum of 1 129 t in 1991, and then systematically increased to 3 847 t in 1996. Cuttlefish production in the Red Sea has been modest, but shows a generally increasing trend since 1992. The spiny lobster fishery is also modest and has been decreasing in recent years.

3.3.7 General

In all six sea areas, the artisanal sector has provided the major share of marine fish production, with over 70% of the catch. For example, in Oman, artisanal fisheries contributed over 71% to total landings, worth over 76% of the total value of fish landed in 1997 (Anon, 1990 - 1998). In UAE, all catches are from artisanal fisheries.

4. FOREIGN FISHING IN THE REGION

In the Arabian Gulf, foreign vessels were banned from fishing in territorial waters as far back as the early 1980s because of the decline in shrimp catches (FAO, 1982; Siddeek, Fouda and Hermosa, 1999). In the northern Arabian Sea, foreign trawlers, drift gillnetters and longliners from Far Eastern countries have exploited the fish resources in Oman's EEZ in the recent past, and some of those countries (e.g., South Korea) continue to exploit the demersal and large pelagic resources using trawlers and longliners under joint venture agreements with local fishing

companies. Similarly, Yemen exploited its cuttlefish resources in the Gulf of Aden in the 1980s with the help of foreign trawlers, especially from the former USSR (Edwards, Ghaddaf and Shaber, 1986). A number of countries (e.g., Lithuania, Georgia, South Korea, Italy and Japan) were fishing in the Arabian Sea and Gulf of Aden in the 1980s, but they slowly disappeared from the area because of economic constraints. India, Iran and Pakistan also have allowed foreign fishing vessels to exploit fish resources in deep waters within their EEZs, through bilateral agreements and joint ventures.

5. FISHERIES AND MARINE ENVIRONMENTAL MANAGEMENT

Fisheries management programmes for the region originated in the Arabian Gulf following the sharp decline in shrimp catches during the 1970s (FAO, 1982). Management efforts began in the early 1980s, with the imposition of closed seasons, restrictions on some fishing gear, and introduction of new fishing methods and boats. Subsequently, catches have improved. However, fisheries management in this region has been limited by lack of data and scientific assessment on most stocks. Since many stocks, especially shrimp, kingfish, longtail tuna, and yellowfin tuna, are shared among several countries, multilateral coordination of data collection and management is essential for sustainable exploitation. Two potentially serious problems facing fisheries in the Arabian region are pollution, and degradation or loss of nursery areas (Sheppard, Price and Roberts, 1992). Shallow water shrimp farming practices have created ecological problems in recent years, especially on the west coast of India.

Fishery resources of the nations bordering the northern Arabian Sea are managed and developed within the framework of international, regional and national policies, laws and conventions. At international level, these countries have either signed or ratified the United Nations Convention on the Law of the Sea (UNCLOS), the Biodiversity Convention, and the International Convention for the Prevention of Pollution from Ships (MARPOL) Treaty. At regional level, the countries were members of the Indian Ocean Fishery Commission (IOFC) (Siddeek, Fouda and Hermosa, 1999). In particular, the implementation since the 1980s of a closed season for shrimp in the Arabian Gulf is the result of recommendations by the IOFC Committee for the Gulfs (FAO, 1982).

With the dissolution of the IOFC Committee for the Gulfs, the Fisheries Technical Committee of the Gulf Coordination Council (GCC) has taken charge of stock assessment research and management for a number of important fish resources, such as demersal fish, shrimp and kingfish, in the GCC area. The 1999 enforcement of a closed season for shrimp in Oman is one example of a collective decision and enforcement by this Committee.

The most common environmental and fisheries regulations enforced in this region are: prevention of pollution by oil and other harmful substances; annual closed seasons for shrimp in the Arabian Gulf, Gulf of Oman and northern Arabian Sea; a monsoon trawl-fishing ban on the west coast of India, and also recently (1998) in the northern Arabian Sea; fishing area restrictions; fishing gear and mesh regulations; and limits on minimum size of catches.

In Oman, lobster and abalone fisheries are managed by a two-month limited open fishing season. In addition, industrial trawl and longline vessels (largely from South Korea) are limited to operating in certain fishing areas and are given annual catch quotas through local fishing companies, who have contracted them. The total annual industrial catch quota varies each year. The fish catch, discard, area of operation and gear use are monitored on trawlers by on-board observers. There are no catch quota or area restrictions for artisanal fisheries in Oman.

Enforcement of management regulations is the greatest problem in all the countries. For example, in Oman, industrial trawlers penetrate into artisanal fishing grounds (<50 m depth) during the cuttlefish fishery season. This behaviour can be found everywhere in the region where

artisanal and industrial vessels target the same commercially valuable stocks, such as shrimp or cuttlefish. In Kuwait, although laws exist limiting the number of fishing licences and shrimp fishing areas, illegal shrimp fishing by speed boats has continued to occur in the prohibited Kuwait Bay area (Abdul Ghaffar and Al Ghunaim, 1994). Illegal shrimp trawling by fibreglass boats occurs during the closed season in Bahrain (Anon., 1996).

6. CORAL REEFS AND MARINE PARKS

There are diverse coral reefs in the region, ranging from well developed reefs with diverse fauna in the Red Sea, to shallow fringing reefs in high-sediment areas in the Arabian Gulf. Cool upwelling influences some reef formation in the northwest Indian Ocean (Sanders and Morgan, 1989; Fouda, 1998). While reefs on the west coast of India and Pakistan are affected by runoff from land, the Arabian Peninsula's reefs are little influenced by rivers.

Fringing reefs along the vast coastlines of Egypt, Eritrea, Saudi Arabia, Sudan and Yemen, and the relatively small coastlines of Israel and Jordan in the Gulf of Aqaba, make the Red Sea an important area for coral reefs with diverse marine fauna. The only threats for these reefs are from fishing and tourism. Many Egyptian reefs are protected by the Nature Conservation Sector of the Egyptian Environmental Affairs Agency. Areas include Ras Mohammed Marine National Park on the Sinai Peninsula and Gebel Elba Conservation Area around the Egypt-Sudan border. Three more parks have been declared recently (Nabq, Taba and Abu Gallum), and two more (Red Sea Islands and Hammata) are recommended for nature protection. Israel Nature Reserves Authority has managed the Eilat Coral Reserve since 1964. The Aqaba Marine Nature Reserve is legally protected, but not actively managed, by Jordan. Most reefs along the Saudi coast are in good condition, with only local tourism and limited artisanal fishing. The Farasan Islands and Umm Al-Qamari Island are protected areas on the Saudi coast. There is little fishing on Sudan's reefs, and one marine park (Sanganeb Atoll Marine National Park) has been established. Yemeni coast coral reefs are not well developed because of high turbidity and soft sediments, which support seagrass beds (Fouda, 1998).

Shallow fringing reef formation in Yemeni waters in the Gulf of Aden is restricted by periodic monsoon upwelling (Sanders and Morgan, 1989). Yemen has proposed four marine protected areas, including parts of the Socotra Archipelago. Somalia has highly biodiverse fringing and patch reefs along the Gulf of Aden. These reefs are little affected by natural disturbances and have high coral cover. Shark fishing in the Gulf of Aden has little impact on the reefs. There are no marine protected areas in Somali waters.

Along the 2 092 km coastline of Oman, several regions – Musandam, Muscat, Masirah Island, Dhofar, and Halaniyat Island – have patchy coral reefs, mostly at depths less than 15 m, with over 91 coral species and 200 reef fish species. The coral growth is largely affected by dramatic changes in water temperature and crown-of-thorn starfish infestation (Fouda, 1998). A number of Marine Nature Reserves were declared in the 1990s by the Ministry of Environment and Municipality to protect vulnerable marine areas. Ras' Al-Had Nature Reserve is for protecting green turtle nesting grounds; Damaniyat Island Nature Reserve is for protecting green and hawksbill turtle nesting grounds, coral reefs, birds, and fish; and Dhofar Khowrs Nature Reserve (fresh as well as brackish water lagoons) is for protecting sea birds and fish. These reserves are well managed.

A few coral reefs occur near the Arabian Sea and around islands in the Strait of Hormuz on the Iranian coast. Shidvar Wildlife Refuge, which includes some coral reefs, is the only protected area in Iran.

Isolated and limited coral growth occurs in Kuwait waters. There are no marine protected areas in Kuwait, although trawl fishing prohibition areas (e.g., Kuwait Bay, and everywhere less

than three miles from the shore) exist to protect juvenile shrimp and fish from fishing. Coral communities in Qatar are also limited because of extreme temperature and salinity. There is no marine protected area declared in Qatar. Many bank and patch reefs occur around offshore islands in United Arab Emirates. Very little is known about these reefs and there are no declared Marine Parks or Marine Reserve areas. There are few reefs along the Arabian Gulf coast of Saudi Arabia. Jubail Marine Wildlife Sanctuary is the only marine protected area on the Saudi coast. Oil pollution and sedimentation are the major threats to growth of Arabian Gulf corals. The effect of Gulf War oil pollution on Kuwait coral communities has been severe.

In the Middle East, there are a number of problems in managing the coastal zones, which include overlap among institutions responsible for coastal management, ambiguous laws and regulations in a number of countries, and lack of enforcement except in Egypt, Israel and Jordan, where fishing and tourism are regulated. However, a number of regional and international institutions have been involved in addressing problems facing coral reefs. Notable institutions and programmes are the Global Environmental Facility of the World Bank, for Egypt, Eritrea and Yemen; the Kuwait Action Plan for the Arabian Gulf, Gulf of Oman, and Arabian Sea; the Marine Environmental Initiative Plan and Red Sea Marine Peace Park for the Gulf of Aqaba; and the Red Sea and Gulf of Aden Strategic Action Programme.

Information is lacking on marine parks and nature reserves on the Pakistan coast and west coast of India. However, a number of turtle nesting beaches on the west coast of India are known to be protected from poachers.

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